CULTURES OF UREDINEAE IN 1911[1]

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The present article is the twelfth of a series of reports[2] by the writer upon the culture of plant rusts, extending through thirteen consecutive years. The preceding report for the year 1910, published in Mycologia for January, 1912, contained an unfortunate slip of the pen in the heading of a paragraph at the middle of page 13, where "*Grossulariae* (Schum.) Lagerh." should read *albiperidia* Arth. With this change, the discussion which follows reads correctly. The same error occurs on page 30, twelfth line from the bottom.

The very large majority of the sowings for each year are made during the months of April and May. Hot weather is inimical to the work, except for a few species. Throughout the year 1911 unusual high temperature prevailed; after the first week in May the thermometer ranged above 80° F. during the middle of the day for the remainder of the cultural season. Owing to an unfortunate delay in securing an assistant to prosecute the work, the first sowings were not made until April 19, and the work was scarcely well under way before the hot days began, making it nearly impossible to obtain germination of the spores, or in case of germination to obtain infection of the hosts.

The work of the season was conducted by Mr. Earl A. Trager, a junior high school student of South Bend, Ind., who was recommended by Miss Clara Cunningham, teacher of the natural sciences in the South Bend High School. Mr. Trager conducted the work admirably. He furthermore showed capacity for mastering the technique and for handling the problems involved which compared favorably with that of his more mature and

[1] Presented before the Botanical Society of America at the Washington meeting, December 27, 1911.

[2] See Bot. Gaz. **29**: 268–276; **35**: 10–23; Jour. Myc. **8**: 51–56; **10**: 8–21; **11**: 50–67; **12**: 11–27; **13**: 189–205; **14**: 7–26; Mycol. **1**: 225–256; **2**: 213–240; and **4**: 7–33. 1912.

experienced predecessors. The paucity of results is wholly ascribable to the lateness in beginning the work and to the unseasonable weather.

Only one direct excursion was made to supply material for this year's cultures. Early in March the writer, accompanied by Mr. Ray Stretch, a graduate of the Lafayette High School, who rendered efficient service and proved a keen observer, visited the region bodering the Mississippi Sound from Ocean Springs to Pass Christian, Miss., well known from the thorough field work and numerous publications of Professor S. M. Tracy, whose home is at Biloxi, between the two places mentioned. The special object in view was to secure material of *Gymnosporangium bermudianum,* the only autoecious species known belonging to this genus, both for culture and for morphological work. Hope was also entertained that fresh material of species of *Peridermium,* with field observations to assist in culture work, might be secured. The region was found to possess the fewest rusts, both in number of species and in their abundance, of any section yet visited for observational purposes.

Upon request a visit to Newfield, N. J., was made by Dr. Frank D. Kern, studying during the collegiate year at Columbia University, New York, accompanied by Mr. B. O. Dodge, a graduate student of the same institution. The object was to secure material of several species of *Gymnosporangium* for cultures. Newfield was chosen, as it was for many years the home of Mr. J. B. Ellis, and his collections show a number of hitherto poorly understood species, whose aecia are still unknown. Probably the most interesting of these is a small foliicolous form on the white cedar, recently described as *G. fraternum* Kern. A note found in the Ellis collection at the New York Botanical Garden gave evidence that it was common in a certain swamp twenty-five years ago. The particular spot was found, and the fungus secured. One day was spent in this vicinity, and seven species of *Gymnosporangium* were collected. Among these were *G. Ellisii,* whose aecial stage is suspected to be the rare *Roestelia hyalina,* and the recently named *G. effusum.* The last is a large form on branches, very destructive to the red cedar, and yet never issued in exsiccati. It is the only one collected on this trip from which infection was obtained.

An extended excursion, but too late for the season's cultures, was made by the writer and Dr. Frank D. Kern during August and September to the foothills of Colorado, between Boulder and Pueblo, and to some extent in the adjacent mountains. This is the richest rust flora, both in species and frequency of occurrence, yet encountered. The dryness of the atmosphere, which promotes the growth of the rust on the individual hosts, while checking the spread from plant to plant, makes the region an exceptionally fine one for field study of relationships between the alternate stages of heteroecious species. Our work was enormously promoted by assistance from Mr. E. Bethel, of Denver, whose exact, enthusiastic, and prolonged observations over the whole region visited cannot be too highly commended. The freedom with which he turned over for our use his most important discoveries and conclusions must unfortunately be inadequately repaid. It was due to his assistance that this excursion proved the richest in results by far of any yet undertaken, results that are only slightly reflected in this report, but have paved the way for important cultures in 1912.

On the eleventh of November, after a day of summer heat, a hurricane did great injury to the conservatory and greenhouse of the Experiment Station, in which many plants for the next season's experiments were growing. At about nine o'clock in the evening a large part of the glass in these houses, and in the offices and laboratories of the department of botany, was broken in by the violence of the wind. The heavy rain which was falling soon turned to snow, and the temperature dropped to many degrees below freezing. When the damage was detected at about eight o'clock the next morning, the plants were largely beyond recovery.

Hearty thanks are due to the following persons who contributed material for study: Mr. E. Bethel, Denver, Colo., heading the list with 87 collections; Messrs. E. W. Olive, Brookings, S. D., J. M. Bates, Red Cloud, Neb., J. Dearness, London, Ont., and W. P. Fraser, Pictou, Nova Scotia, each sent between 10 and 30 collections, while much smaller numbers were sent by Messrs. E. Bartholomew, Stockton, Kans., C. F. Baker, Claremont, Calif., J. F. Brenckle, Kulm, N. D., J. C. Blumer, Tucson,

Ariz., H. S. Coe, Ames, Iowa, H. M. Jennison, Crawfordsville, Ind., S. Kusano, Tokio, Japan, E. F. Smith, Hannaford, N. D., E. M. Wilcox, Lincoln, Neb., J. J. Wolf, Durham, N. C., and F. Vasku, Oberlin, Ohio. Seeds and living plants were also sent by a number of botanists to provide host plants of native species required in the work. To all these and to others who aided in the work of the year grateful acknowledgment is due and is hereby extended. The investigations were carried out under the auspices of the Indiana Experiment Station, and financed from the Adams fund.

During the present season 193 collections of material with resting spores and 37 collections with active spores were employed, from which 691 drop cultures were made to test the germinating condition of the spores. Out of the 193 collections with resting spores 156 failed to germinate, leaving 37 collections available for experimental tests. Altogether about 235 sowings were made and 32 infections obtained. All but three sowings were made on plants growing in pots in the greenhouse. The most important conclusions derived from a study of the results are given in the following paragraphs.

NEGATIVE RESULTS.—It has been customary in these reports to record sowings with germinating spores when no infections were obtained, to serve as a guide in selecting hosts for future attempts. This year only a few instances will be given, as all sowings made after the heated term began, May 8, are deemed too uncertain to be of value.

1. PUCCINIA TOSTA Arth., on *Sporobolus asperifolius* (Nees & Meyen) Thurb., collected at Denver Colo., by Mr. E. Bethel, was sown April 19, on *Atriplex confertifolia* and *Malvastrum coccineum,* with no infection. The day following a collection with same data from Delta, Colo., was sown on *Aesculus glabra* and *Xanthoxylum americanum,* and again, May 10, on ten other hosts, with no infection.

The resemblance of this rust and of its host to that of *Puccinia subnitens* Diet., on *Distichlis spicata,* is very marked, as seen in the field. The two species grow under the same conditions, often intermixed, and might be expected to have the same aecial

hosts, a possibility barely touched by the present attempt at culture.

2. PUCCINIA SCHEDONNARDI K. & S., on *Schedonnardus paniculatus* (Nutt.) Trel., collected at Stockton, Kans., by Mr. E. Bartholomew, was sown April 19, on *Aesculus glabra, Xanthoxylum americanum, Hydrophyllum capitatum, Sidalcea oregana, Callirrhoe involucrata,* and *Onagra pallida,* with no infection. Similar material in former years was sown on twenty-eight other species of hosts.[3]

3. GYMNOCONIA INTERSTITIALIS (Schl.) Lagerh. No attempts have been made, so far as the writer knows, to propagate any species of rust by means of its pycniospores, except one made by Dr. Frank D. Kern in 1910, and not heretofore reported. He sowed pycniospores from *Amelanchier erecta,* belonging to *Gymnosporangium clavariaeforme,* upon young leaves of *A. erecta* by pricking and otherwise mutilating the epidermis, but without results. It is well known that the growth of such spores soon ceases in a liquid culture the same as with any other rust spores, only sooner, as they are much smaller and contain less nutriment. But it has not been shown that they will not form a mycelium when suitably placed upon or within the tissues of a host plant. The prominent and abundant pycnia of the blackberry rust, which mature in advance of the aecia, seem especially favorable for such a trial. Pycniospores from *Rubus allegheniensis* taken when perfectly fresh were sown May 9 on young leaves of two different plants of the same species, which were well established in pots. The spores were not only placed on the surface of the partly grown leaves, but were also pricked into the tissues in places with a needle. This was done to imitate the probable dispersion of such spores by insects, for which the nectar secreted by the sori may have an attraction. No infection was obtained. Neither in this attempted culture nor in that by Dr. Kern was any examination made to ascertain what growth the pycniospores may have made.

SUCCESSFUL CULTURES SUPPLEMENTING PREVIOUS WORK.—The facts derived by growing the following species of rusts supple-

[3] See Bot. Gaz. 35: 11. 1903; Jour. Myc. 13: 193. 1907; 14: 11. 1908; Mycol. 1: 231. 1909; and 4: 10. 1912.

ment those obtained from previous cultures in this series or from cultures recorded by other American or European investigators.

1. PUCCINIA PECKII (DeT.) Kellerm., on *Carex lanuginosa* Michx., collected at Red Cloud, Neb., by Rev. J. M. Bates, was sown May 20 on *Onagra biennis* and *Meriolix serrulata,* with no infection on the latter, but with abundant pycnia on the former May 29, and aecia June 1.[4] Similar cultures on *Onagra biennis* were made from undetermined species of *Carex* collected by Mr. E. Bethel, at Denver, Colo., and by Dr. J. F. Brenckle, at Kulm. N. D.

2. PUCCINIA ANGUSTATA Peck, on *Scirpus cyperinus* (L.) Kunth, collected at London, Ont., by Mr. J. Dearness, was sown May 25 on *Lycopus americanus,* giving rise to pycnia first seen June 3, and aecia June 5.[5]

3. PUCCINIA PHRAGMITIS (Schum.) Körn., on *Phragmites communis* Trin., collected at Cowles, Neb., by Rev. J. M. Bates, was sown May 9 on *Rumex crispus,* giving rise to abundant pycnia and aecia first observed May 23.[6]

4. PUCCINIA CINEREA Arth., on *Puccinellia airoides* (Nutt.) Wats. & Coult., collected at Lewis Station, Colo., by Mr. E. Bethel, was sown May 10 on *Oxygraphis Cymbalaria,* giving rise to pycnia May 16, and an abundance of aecia May 20.[7]

5. PUCCINIA SUBNITENS Diet., on *Distichlis spicata* (L.) Greene, collected at Lewis Station, Colo., by Mr. E. Bethel, was sown May 2, on *Sarcobatus vermiculatus, Monolepis Nuttalliana, Cleome spinosa, Atriplex hastata,* and *Chenopodium album,* with no infection on the first two, but with numerous pycnia on the others, appearing May 11, 12 and 16, respectively, followed by aecia on the *Cleome* and *Atriplex,* on both appearing May 15.[8]

[4] For previous cultures see Bot. Gaz. 35: 13. 1903; Jour. Myc. 8: 52. 1902; 11: 58. 1905; 12: 15. 1906; 13: 195. 1907; Mycol. 1: 233. 1909; 2: 222. 1910; and 4: 15. 1912.

[5] For previous cultures see Bot. Gaz. 29: 273. 1900; Jour. Myc. 8: 53. 1902; 11: 58. 1905; 13: 196. 1907; 14: 14. 1908; Mycol. 1: 234. 1909; and 4: 17. 1912.

[6] For previous cultures see Bot. Gaz. 29: 269. 1900; Jour. Myc. 9: 220. 1903; 14: 15. 1908; and Mycol. 2: 225. 1910.

[7] For a previous similar culture see Mycol. 1: 246. 1909.

[8] For previous cultures see Bot. Gaz. 35: 19. 1903; Jour. Myc. 11: 54. 1905; 12: 16. 1906; 13: 197. 1907; 14: 15. 1908; Mycol. 1: 234. 1909; 2: 225. 1910; and 4: 18. 1912.

6. UROMYCES PECKIANUS Farl., on *Distichlis spicata* (L.) Greene, obtained in the field March 29, 1911, at Pictou, Nova Scotia, by Professor W. P. Fraser, was sown April 19 on *Tissa canadensis* and *Lepidium virginicum,* with no infection. Another collection with same data but obtained in the field April 13, 1911, was sown on *Bursa Bursa-pastoris, Lepidium virginicum, Corydalis montanum, Tissa canadensis, Cleome spinosa,* and *Atriplex hastata,* with no infection except on the last, which showed numerous pycnia May 16, and an abundance of aecia May 22. Still another collection with same data but obtained in the field April 27, 1911, was sown May 5 on *Chenopodium album* and on the same six hosts as the last, with infection only on *Atriplex,* showing pycnia May 17, and aecia May 29, both in abundance.

A former attempt at cultures with this species proved futile,[9] but Professor Fraser[10] met with better success in cultures made by himself during the same season of 1910. He was able to abundantly infect both *Atriplex hastata* and *Chenopodium album* from teliospores on *Distichlis spicata.* Material from his cultures was most generously sent to the writer. Since then he has sent material of his more extensive and important cultures of 1911, which need not be specifically mentioned here, although they strengthen the conclusions about to be stated.

A careful morphological study of herbarium material, both as collected in the field and as grown from cultures, shows no appreciable difference in the gross or microscopical characters between the several stages of *Puccinia subnitens* Diet. and *Uromyces Peckianus* Farl., except in one particular—the unilocular or bilocular condition of the teliospore. When the teliospore is two-celled, as in the *Puccinia,* it is correspondingly longer than, but essentially the same otherwise as the one-celled teliospore, found in the *Uromyces.* The aecia in their peridial cells and aeciospores, and the uredinia in their appearance and in their urediniospores, when taken by themselves are indistinguishable. The only character with which to separate the so-called two species is the presence or absence of a septum in the teliospore.

Both the *Puccinia* and the *Uromyces* show marked racial tendencies in the selection of aecial hosts, seemingly correlated with

[9] See Mycol. 4: 12. 1912.

[10] Mycol. 3: 72–74. 1911.

geographical position, but more information is needed regarding the races of the *Uromyces* before a full comparison can be instituted. Whether the aecia of the *Uromyces* ever occur upon any family other than the *Chenopodiaceae,* as do those of the *Puccinia,* yet remains uncertain, but it is confidently expected that such will be the case. In any event there is every reason, except that of nomenclatorial expediency, to consider *Puccinia subnitens* and *Uromyces Peckianus* telial races of one and the same species which in turn may be separable into geographical races in accordance with their selection of aecial hosts.

7. UROMYCES MEDICAGINIS Pass. The urediniospores from plants of *Medicago sativa* L., carried over the winter in the greenhouse, were sown March 8 on *Medicago sativa, Trifolium pratense, T. medium,* and *T. repens,* producing infection only on the first, uredinia showing March 22. A similar set of sowings was made April 28 on other plants of the same four hosts, with similar result, only the *Medicago* being infected, showing uredinia May 12. The work of 1910 is thus confirmed.[11]

8. GYMNOSPORANGIUM NIDUS-AVIS Thax., on *Juniperus virginiana* L., was sent by Dr. Frank D. Kern from Newfield, N. J., and sown May 4 on leaves of *Cydonia vulgaris, Malus coronaria, Amelanchier erecta,* and also on the fruit of the last. The only infection was on the fruit of the *Amelanchier,* showing numerous pycnia May 12, and aecia in great abundance May 24. Another collection on the same host sent by Professor E. Mead Wilcox from Lincoln, Neb., was sown May 11 on leaves of the same three hosts, with infection only on the *Malus,* giving pycnia June 2, but the leaves dying before aecia formed.[12]

9. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC., on *Juniperus sibirica* Burgsd., was sent by Mr. E. Bethel from Lake Eldora, Colo., and sown May 25 in the open orchard on fruits of pears and apples, and in the greenhouse on leaves of *Cydonia vulgaris* and fruits of *Amelanchier erecta,* with no results except on fruits of *Amelanchier,* giving abundant pycnia May 31, and very abundant aecia June 15.[13]

[11] See Mycol. 4: 24. 1912.

[12] For previous cultures see Jour. Myc. 2: 230. 1910; and 4: 25. 1912.

[13] For previous cultures see Jour. Myc. 14: 18. 1908; Mycol. 1: 239. 1909; and 4: 24. 1912.

10. GYMNOSPORANGIUM INCONSPICUUM Kern, on *Juniperus utahensis* (Engelm.) Lemmon, sent by Mr. E. Bethel from Paonia, Colo., was sown April 7 on leaves of *Amelanchier erecta* and of *A. vulgaris,* with infection only on the latter, showing pycnia April 24, but not maturing aecia.[14]

11. GYMNOSPORANGIUM LIBOCEDRI (P. Henn.) Kern, on *Libocedrus decurrens* Torr., sent by an unknown correspondent, was sown April 17 on *Amelanchier vulgaris, Crataegus tomentosa, C. cerronis,* and *Sorbus aucuparia,* with no infection on the last, but pycnia showing on the other hosts April 25, 26 and 28 respectively, and abundant aecia on the *Amelanchier,* showing May 16.[15]

12. GYMNOSPORANGIUM JUNIPERINUM (L.) Mart., on *Juniperus sibirica* Burgsd., sent by Mr. E. Bethel from Palmer Lake, Colo., was sown April 26 on *Sorbus aucuparia,* without producing infection. It was again sown May 5 on *S. americana,* and produced pycnia May 20 in abundance, but did not develop aecia.

The species has not been cultivated before from American material. The first cultures were made in Europe by Robert Hartig[16] about 1882 at Munich, and the species named *G. tremelloides,* from its conspicuous telia. The Linnaean name appears to have been transferred by Oersted in 1866 to a much less conspicuous form, as pointed out by Kern,[17] but it seems best now to follow the original usage. The galls used in the present culture were on small branches and about one centimeter across.

13. COLEOSPORIUM VERNONIAE B. & C. A collection of *Peridermium carneum* Bosc, on *Pinus taeda* L., collected by Mr. Ray Stretch and the writer at Mississippi City, Miss., was sown March 6 on *Laciniaria scariosa* and *Vernonia gigantea,* with infection only on the latter, uredinia showing March 22. Three other collections on *Pinus taeda* L., made by the same persons at Biloxi, Miss., were each sown March 8 on *Laciniaria scariosa* and *L. punctata,* with no infection. The results confirm the work of 1910.[18]

[14] For previous cultures on fruit of *Amelanchier* see Jour. Myc. **14**: 24. 1908.

[15] For previous cultures see Mycol. **1**: 252. 1909.

[16] Hartig, Lehrb. Baum-Kr. 133. 1882.

[17] Science **27**: 930. 1908; Bull. Torrey Club **35**: 499. 1908; and Bull. N. Y. Bot. Gard. **7**: 458. 1911.

[18] See Mycol. **4**: 29. 1912.

14. MELAMPSORA ALBERTENSIS Arth., on *Populus tremuloides* Michx., from Palmer Lake, Colo., sent by Mr. E. Bethel, was sown April 20 on *Larix laricina, Ribes Cynosbati* and *Pseudotsuga mucronata,* with infection only on the last, showing pycnia in abundance May 4, and aecia May 9.[19] On our excursion to Colorado in September Dr. Kern and the writer in company with Mr. Bethel observed great areas of the mountain sides covered with the yellowed foliage of *P. tremuloides,* almost every leaf of which showed uredinia and telia of this rust. It seems remarkable there should be so few collections of it in herbaria, and also of its aecia on *Pseudotsuga.*

15. MELAMPSORELLA ELATINA (A. & S.) Arth. Part of a large witches' broom of *Aecidium elatinum* A. & S., on *Abies lasiocarpa* Nutt., was sent by Mr. E. Bethel from Lake Eldora, Colo., 9,000 feet altitude, and sown August 8 on *Cerastium oreophilum,* giving an exceedingly abundant infection of uredinia, first recorded on September 7. This is the first culture of the species with American material. In Europe cultures with aeciospores have been made by von Tubeuf,[20] Klebahn,[21] and Ed. Fischer,[22] and indications of races have been found. This is an interesting species of rust from the unusual fact of both phases having perennial mycelium.

SUCCESSFUL CULTURES REPORTED NOW FOR THE FIRST TIME.—The following species have never before been cultivated, in America or elsewhere, so far as the writer knows. It is much to be regretted that some of the species could not be brought to full development, but although the results are in part imperfect, they represent most important additions to previous knowledge.

1. PUCCINIA LYGODESMIAE Ellis & Ev., on wintered-over stems of *Lygodesmia juncea* (Pursh) D. Don, collected April 6, 1911, by Mr. E. Bartholomew, at Stockton, Kans., was sown on plants

[19] For previous cultures see Mycol. 4: 29. 1912.

[20] Deuts. Bot. Ges. 19: 433. 1901; Arb. Biol. Abth. Land.-Forstw. Kais. Gesundh. 2: 368.

[21] Jahr. Wiss. Bot. 35: 699. 1901; Zeits. Pfl.-Kr. 12: 139. 1902; and Jahr. Hamb. Wiss. Anst. 20[3]: 31. 1902.

[22] Ber. Deut. Bot. Ges. 19: 397. 1901; Zeits. Pfl.-Kr. 11: 321. 1901; and 12: 193. 1902.

of the same species April 19, and characteristic telia were observed May 3, without being preceded by pycnia or other sporeforms. The species clearly produces but the one form of spore in its life cycle. The aecia often found on this host are undoubtedly heteroecious.

2. AECIDIUM MONOICUM Peck, on *Arabis* sp. Living plants of some smooth leaved species of *Arabis* bearing aecia were sent by Mr. E. Bethel from Boulder, Colo., 5,000 feet altitude, and arranged May 9 over plants of *Koeleria cristata, Stipa viridula,* and *Trisetum subspicatum,* followed by infection only on the last, uredinia and telia being first observed June 1. Similar plants bearing aecia were also sent by Mr. Bethel from Lake Eldora, Colo., 9,000 feet altitude, and placed over plants of *Koeleria cristata* and *Trisetum majus,* followed by infection on the latter only, uredinia and telia being first observed July 24.

The results of the cultures appear unequivocal. The aecia used belong to a form on *Arabis,* and probably also on related genera, very common throughout the Rocky mountain region, which infests the whole plant and usually prevents it from flowering, consequently the determination of hosts is usually difficult and often impossible. Whether all collections labelled *Aecidium monoicum* Peck belong here may be left to future examination, but most of them doubtless do so, although there may be races going to different species of grasses. A bright yellow form on *Cheiranthus Menziesii* from Nevada was named *Aecidium auriellum* by Mr. Peck, and may be identical with the *Arabis* forms, as the difference in color appears to be incidental.

The telial phase has passed under the name *Puccinia Triseti* Erikss., a name which belongs to a species with covered telia, that has not with certainty been found in America. The rust with similar naked telia on *Koeleria* and *Stipa, Puccinia Stipae* Arth., is almost identical in morphological characters, but it forms the curious *Aecidium sclerothecioides* E. & E. on composites. There is, moreover, an adaptive distinction—the *Trisetum* form is capable of germination as soon as the teliospores are mature, while in *P. Stipae* the teliospores require a period of rest, and first show their viable character the following spring. Teliospores from the first of the above recorded cultures were tested

in drop culture, and gave abundant and vigorous germination after twelve hours. Sowings were at once made June 29 on two plants of *Arabis* in the rosette stage, grown from seed sent by Mr. Bethel from Colorado. One plant flowered later and showed no evidence of infection. The other plant gradually developed numerous lateral buds, forming a compact mass of small rosettes. This rather abnormal development seems to indicate a probable infection, but the proof must await the elongation of the stems at flowering time next spring.

The credit for detecting the probable connection of these aecial and telial forms is to be shared by Mr. A. O. Garrett and Mr. E. Bethel. On packet 75 of the Fungi Utahensis, *Aecidium monoicum* on *Arabis Drummondii,* Mr. Garrett adds the note, "apparently connected with a rust on *Trisetum subspicatum.*" This collection was made July 22, 1905, and in a letter dated April 30, 1906, he writes: "On July 22 I made a collection of aecidia on *Arabis Drummondii.* The plants were in an open place on the mountain side between spruce timber on either side. On August 21 I returned to the spot to hunt for the alternate form of the *A. monoicum.* Upon reaching the locality I found a plant of *Trisetum subspicatum,* and on it I found teleutospores [distributed in Fungi Utahensis *194*]. Immediately next to it I found a dried up plant of *A. Drummondii* with abundant aecidia. Looking further, I found that wherever I found the III, I found I, although in a few cases I found I without running across III." It should be borne in mind that these observations were made in the arid region of the Rocky mountains, where juxtaposition is more significant than in more humid regions. Mr. Bethel made similar observations at various times in Colorado, and is, moreover, convinced from his field studies that the same species of rust occurs on *Koeleria* and *Stipa.* This may be true, and collections in the herbarium seem to justify the opinion, at least for *Koeleria,* but cultures are yet wanting, material for which should be gathered in late summer or autumn, and not in spring. In a letter dated April 9, 1911, Mr. Bethel makes the significant statement: "The *Koeleria* and *Trisetum* rusts have a strange way of disappearing. It is almost impossible to find them in the spring. I brought home plants of both *Koeleria* and

Trisetum last fall which were very badly rusted, and planted in the garden. However, this spring I can see the telia on only one leaf, and that is the *Trisetum*." Even the rust on the one leaf may have been another species. The evanescent character of this species corresponds to that of *Puccinia Eatoniae* Arth., having aecia on *Ranunculus abortivus* from a diffused mycelium and appearing over the whole surface of the leaf early in spring.

As the rust is now for the first time clearly recognized, it is herewith distinctively named and characterized.

Puccinia monoica (Peck) n. nom. (*Aecidium monoicum* Peck, Bot Gaz. 4: 230. 1879.)

O. Pycnia amphigenous, thickly scattered over large areas, preceding or among the aecia, honey-yellow becoming brownish, sub-epidermal, flattened-globose, 90–160μ in diameter by 60–112μ high; ostiolar filaments 30–90μ long.

I. Aecia chiefly hypophyllous, evenly and thickly scattered, usually occupying the whole under surfaces of the leaves, cupulate or short cylindrical, 0.3–0.4 mm. in diameter; peridium whitish, the margin erect or spreading, somewhat lacerate, the peridial cells rhomboidal, 29–34μ long, the outer wall 7–10μ thick, striate, the inner wall 3–3.5μ thick, verrucose; aeciospores globoid, 15–23 by 18–25μ, the wall colorless, 1.5–2.5μ thick, rather finely verrucose.

II. Uredinia chiefly epiphyllous, somewhat gregarious, oval or oblong, 0.5–1 mm. long, cinnamon-brown, pulverulent; urediniospores broadly ellipsoid or obovoid, 19–21 by 24–31μ, the wall cinnamon-brown, about 2μ thick, finely and closely echinulate, the pores 6–8, scattered.

III. Telia chiefly epiphyllous, more or less gregarious, oval, oblong, or roundish, 0.5–1 mm. long, pulvinate, chocolate-brown or cinereous by germination at maturity, early naked; teliospores ellipsoid or clavate-oblong, 16–24 by 34–45μ, the wall cinnamon-brown, 1–1.5μ thick, thicker at apex, 5–10μ, smooth; pedicel nearly or quite colorless, rather slender, once to twice length of spore.

O and I. Pycnia and aecia on various species of *Arabis* throughout the Rocky mountain region, type collection from Colorado, on *Arabis retrofracta*, made by T. S. Brandegee.

II and III. Uredinia and telia on various species of *Trisetum*, the present known geographical range not so great as for the aecial stage.

3. GYMNOSPORANGIUM NELSONI Arth. (*G. durum* Kern), on *Juniperus utahensis* (Engelm.) Lemmon, sent by Mr. E. Bethel from Delta, Colo., was sown April 5 on *Amelanchier vulgaris*,

A. erecta, Crataegus cerronis, Philadelphus coronarius, and on the last species once more April 12. The only infection was on *Amelanchier vulgaris,* showing pycnia April 24, but failing to mature aecia. Other sowings made in May were without results. The connection with aecia on *Amelanchier* had been predicted by Mr. Bethel from his field observations in Colorado from 1907 to the present season, and also by Mr. A. O. Garrett in Utah, 1910. The same kind of observation is recorded by Tracy & Earle for southern Colorado in 1898.[23] The galls used for these sowings were on small twigs, globoid, and from 1 to 2 cm. in diameter. This form, generally distributed under the name of *G. durum* Kern, has recently been united by Dr. Kern[24] with *G. Nelsoni* Arth. On the type specimens of the latter the galls are small, only 1–8 mm. in diameter, and hence not at first readily identified with the large woody galls, which have been called *G. durum.*

All cultures heretofore reported in this series under the name *G. Nelsoni* belong not to this species but to *G. juvenescens* Kern, as stated in the report for 1910.[25] The latter is a species producing witches' brooms, but not woody galls.

4. GYMNOSPORANGIUM KERNIANUM Bethel, on *Juniperus utahensis* (Engelm.) Lemmon, sent by Mr. Bethel from Paonia, Colo., was sown April 7 on *Amelanchier vulgaris,* and *Crataegus cerronis,* with infection only on the *Amelanchier,* showing pycnia April 17, but not maturing aecia. Another sowing on *Amelanchier vulgaris* April 17 was without result, and the same was true of another collection from Paonia, Colo., sown on the same day. The failure to secure aecia makes it impossible to identify the aecia of this species among the many forms occurring on *Amelanchier,* although it is doubtless already in the hands of collectors. So far as the evidence goes it bears out Mr. Bethel's surmise[26] regarding the aecial hosts. This culture is referred to by Kern[27] in his monograph on the genus *Gymnosporangium.*

5. GYMNOSPORANGIUM EFFUSUM Kern, on *Juniperus virginiana*

[23] Greene, Plantae Bakerianae 1: 19. 1901.
[24] Bull. N. Y. Bot. Gard. 7: 448, 470. 1911.
[25] Mycol. 4: 26. 1912.
[26] See Mycol. 3: 158. 1911.
[27] See Bull. N. Y. Bot. Garden 7: 449. 1911.

L., collected at Newfield, N. J., by Messrs. F. D. Kern and B. O. Dodge, was sown May 4 on *Aronia arbutifolia, Amelanchier canadensis, Pyrus communis, Malus coronaria,* and *M. Malus,* with infection on the first only, showing pycnia in abundance June 15, but failing to develop aecia.

Although this infection did not proceed to a sufficient development to show the identity of the aecia, yet there are some reasons, chiefly relating to host and geographical distribution for thinking that we are dealing with *Roestelia transformans* Ellis, which was described by Mr. Ellis from material collected at Newfield, N. J., on *Aronia arbutifolia.*

6. GYMNOSPORANGIUM GRACILENS (Peck) Kern & Bethel (*G. speciosum* Peck), on *Juniperus monosperma* (Engelm.) Sarg., sent by Mr. Bethel from Trinidad, Colo., was sown April 26 on *Crataegus tomentosa, Sorbus aucuparia,* and *Philadelphus coronarius,* with heavy infection on the last, showing pycnia May 6, and aecia May 29. Before the infection had become certain another sowing was made May 1 on *Amelanchier vulgaris,* and the day following again on another plant of the same host, and also on the fruit of *A. erecta,* as well as the leaves of *Philadelphus coronarius.* Again infection was secured only on the *Philadelphus,* the pycnia showing in the greatest abundance May 13, and aecia June 8.

This connection was suggested by Mr. Bethel, who has given a history of his observations in a recent number of MYCOLOGIA.[28] The result of this set of cultures was communicated to Dr. F. D. Kern, then residing in New York, which enabled him to complete the description and synonymy of the species and to list the aecial hosts in his monograph of the genus *Gymnosporangium.*[29] The connection is especially notable, as it carries the aecial hosts of *Gymnosporangium* outside the families of Malaceae and Rosaceae, into the Hydrangiaceae. As the studies of this genus progress more and more evidence is secured to show that it possesses outlying species approaching in form and habit some of those in other genera.

[28] Bethel, Notes on some species of *Gymnosporangium* in Colorado, Mycol. 3: 156–160. 1911.

[29] See Bull. N. Y. Bot. Garden 7: 458. 1911.

The ease with which infection of the garden *Philadelphus,* originally a native of the Caucasus, was secured proved a surprise. Every effort was made to obtain native species of the genus, but without success until too late for culture work.

SUMMARY

The following is a complete list of the successful cultures made during the year 1911. It is divided into two series, species that have previously been grown in cultures and reported by the writer or other investigators, and species whose culture is now reported for the first time.

A. SPECIES PREVIOUSLY REPORTED

1. *Puccinia Peckii* (DeT.) Kellerm.—Teliospores from *Carex lanuginosa* Michx., sown on *Onagra biennis* (L.) Scop.

2. *Puccinia angustata* Peck.—Teliospores from *Scirpus cyperinus* (L.) Kunth, sown on *Lycopus americanus* Muhl.

3. *Puccinia Phragmitis* (Schum.) Körn.—Teliospores from *Phragmites communis* Trin., sown on *Rumex crispus* L.

4. *Puccinia cinerea* Arth.—Teliospores from *Puccinellia airoides* (Nutt.) Wats. & Coult., sown on *Oxygraphis Cymbalaria* (Pursh) Prantl.

5. *Puccinia subnitens* Diet.—Teliospores from *Distichlis spicata* (L.) Greene, sown on *Cleome spinosa* L., *Atriplex hastata* L., and *Chenopodium album* L.

6. *Uromyces Peckianus* Farl.—Teliospores from *Distichlis spicata* (L.) Greene, sown on *Atriplex hastata* L.

7. *Uromyces Medicaginis* Pass.—Urediniospores from *Medicago sativa* L., sown on same species of host.

8. *Gymnosporangium Nidus-avis* Thax.—Teliospores from *Juniperus virginiana* L., sown on fruits of *Amelanchier erecta* Blanch. and leaves of *Malus coronaria* (L.) Mill.

9. *Gymnosporangium clavariaeforme* (Jacq.) DC.—Teliospores from *Juniperus sibirica* Burgsd., sown on fruits of *Amelanchier erecta* Blanch.

10. *Gymnosporangium inconspicuum* Kern.—Teliospores from *Juniperus utahensis* (Engelm.) Lemmon, sown on leaves of *Amelanchier vulgaris* Moench.

11. *Gymnosporangium Libocedri* (P. Henn.) Kern.—Teliospores from *Libocedrus decurrens* Torr., sown on *Amelanchier vulgaris* Moench, *Crataegus tomentosa* L., and *C. cerronis* A. Nels.

12. *Gymnosporangium juniperinum* (L.) Mart. (*G. tremelloides* R. Hartig).—Teliospores from *Juniperus sibirica* Burgsd., sown on *Sorbus americana* Marsh.

13. *Coleosporium Vernoniae* B. & C.—Aeciospores from *Pinus taeda* L., sown on *Vernonia gigantea* (Walt.) Britton.

14. *Melampsora albertensis* Arth.—Teliospores from *Populus tremuloides* Michx., sown on *Pseudotsuga mucronata* (Raf.) Sudw.

15. *Melampsorella elatina* (A. & S.) Arth.—Aeciospores from *Abies lasiocarpa* Nutt., sown on *Cerastium oreophilum* Greene.

B. Species Reported Now for the First Time

1. *Puccinia Lygodesmiae* Ellis & Ev.—Teliospores from *Lygodesmia juncea* (Pursh) D. Don, sown on the same species of host.

2. *Puccinia monoica* (Peck) Arth.—Aeciospores from *Arabis* sp., sown on *Trisetum subspicatum* (L.) Beauv., and *T. majus* (Vasey) Rydb.

3. *Gymnosporangium Nelsoni* Arth. (*G. durum* Kern).—Teliospores from *Juniperus utahensis* (Engelm.) Lemmon, sown on *Amelanchier vulgaris* Moench.

4. *Gymnosporangium Kernianum* Bethel.—Teliospores from *Juniperus utahensis* (Engelm.) Lemmon, sown on *Amelanchier vulgaris* Moench.

5. *Gymnosporangium effusum* Kern.—Teliospores from *Juniperus virginiana* L., sown on *Aronia arbutifolia* (L.) Ell.

6. *Gymnosporangium gracilens* (Peck) Kern & Bethel.—Teliospores from *Juniperus monosperma* (Engelm.) Sarg., sown on *Philadelphus coronarius* L.

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